Application Note
AP-01

Controlling the MT-9500 Recorder With The General Purpose Interface Bus

Astro-Med, Inc.

Astro-Med Industrial Park • 600 East Greenwich Avenue •
West Warwick • R.I. • 02893 • (401)828–4000

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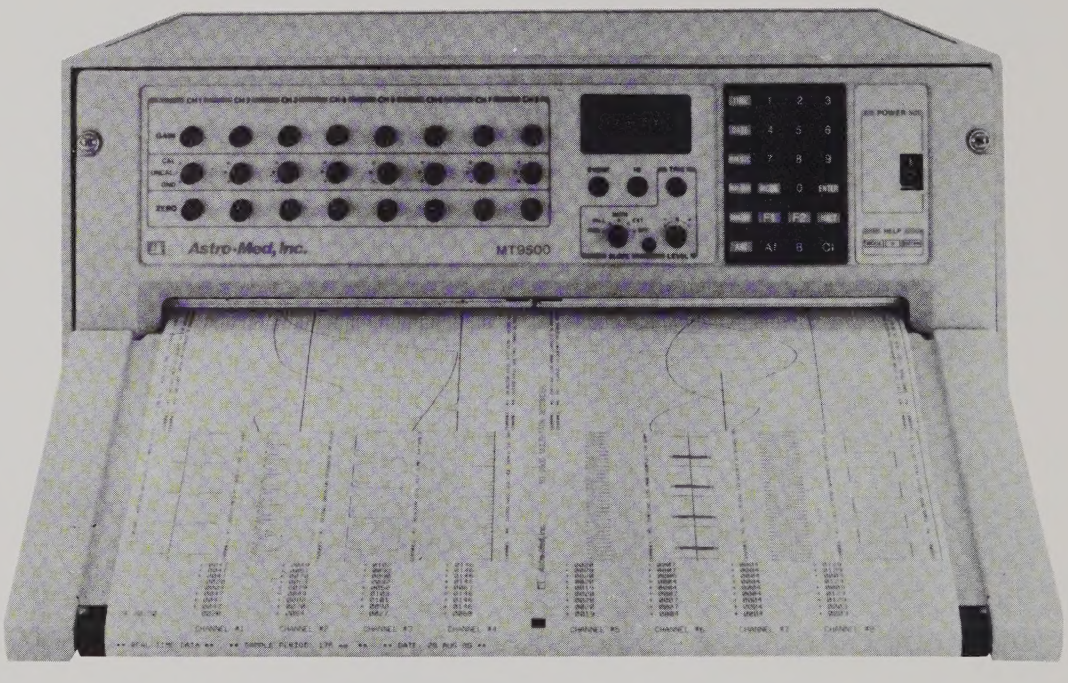

T-9500 New Technology 8-Channel Recorder by Astro-Med, Inc., West Warwick, R.

Controlling the MT-9500 Recorder With The General Purpose Interface Bus

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INTRODUCTION

This application note has been developed as an aid to MT-9500 recorder users utilizing the GPIB communications link. It is meant to supplement information found in the original MT-9500 Host Control Manual. Method A describes the original MT-9500 GPIB implementation, which is electrically compatible with the IEEE-488 standard, but which has a somewhat limited implementation. Method B describes the latest GPIB implementation found on MT-9500 recorders with a firmware revision level of x3.0 or higher. This latest implementation allows more versatile control over the MT-9500, yet conforms to the pre-existing command structure of the MT-9500.

Users who wish to take full advantage of the MT-9500 within a GPIB environment may upgrade their MT-9500 to the latest firmware revision level by contacting the Astro-Med Customer Service Department.

THE GENERAL PURPOSE INTERFACE BUS

Background

The General Purpose Interface Bus (GPIB) on the MT-9500 is an implementation of IEEE-488-1978. It allows commands and data to pass between various components of an instrumentation system. Devices which connect to the system fall into the following classes: talkers, listeners and controllers. The MT-9500 has only talker and listener capability within an instrumentation system. Multiple listeners may be configured simultaneously, but only one talker may be active at a time.

During system operation, the controller-in-charge determines how each device will be functioning, and thus controls all operations performed by that device. Built into GPIB is a convenient method of performing device operation locally (from the front panel), and reverting back to system control.

Bus Line Definitions

The GPIB system consists of 16 signal lines which contain commands, data and handshaking signals. These are divided into three classes. The first is the data bus, which is comprised of 8 signal lines and controlled by three handshake lines. these three lines comprise the second class. the thrid class of five lines are the general interface management lines. the following paragraph describes these three classes of lines, and their implementaion within the MT-9500.

DI01 - DI08 Data Input/Output Lines (8)
Type: Data lines

The DI0 lines carry data back and forth between devices and the controller-in-charge, as well as command information from the controller-in-charge. The MT-9500 uses these lines for input and output of commands and data.

DAV **Data Valid**
Type: Handshake line

The DAV line is used to indicate the availability and validity of information on the data (Di0) lines. The MT-9500 implements the three wire handshake of DAV, NRFD and NDAC.

NRFD **Not Ready For Data**
Type: Handshake line

GPIB INTERFACE AND BUS STRUCTURE

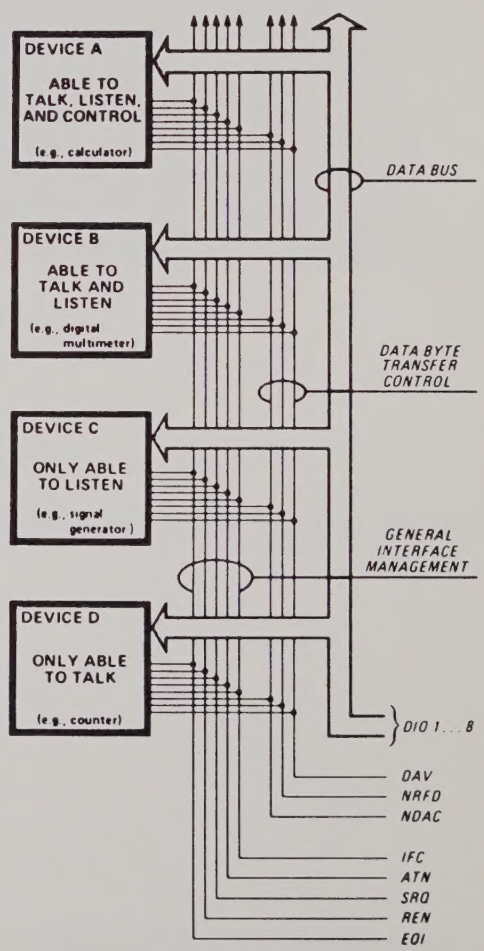


Figure 1

The NRFD line is used to indicate the readiness of devices to accept data.

NDAC **No Data Accepted**
Type: Handshake line

The NDAC line is used to indicate the acceptance of data by devices on the GPIB bus.

ATN **Attention**
Type: Management Line

Used only by the controller-in-charge (active controller), ATN is used to specify how data on the DI0 lines are to be interpreted. In general, when ATN is asserted (active, data on the DI0 lines are a multiline command message. When ATN is no asserted, data on the DI0 lines are device dependant data. The MT-9500 will respond to a limited set of multiline commands (described in the next section). See APPENDIX A for multiline message coding.

IFC **Interface Clear**
Type: Management Line

Used only by the controller-in-charge (active controller), IFC is used to clear the GPIB interface to a known quiescent state. This line is driven by the controller-in-charge.

SRC **Service Request**
Type: Management Line

SRC can be sent by any device on the bus to the controller-in-charge to indicate a need for attention (Example: out of paper, in the case of the MT-9500)

REN Remote Enable
Type: Management Line

Used only by the controller-in-charge (active controller), REN is used to place a device in remote or local control.

EOI **End of Identify**
Type: Management Line

EOI is asserted to indicate the conlusion of a string of data, or as a means of conducting a parallel poll in conjunction with ATN.

General Cable Information

• The maximum total length for all interconnected instruments is 20 meters

• The maximum number of devices that can be connected together to form one interface system is 15.

MT-9500 GPIB IMPLEMENTATION

This section will detail the steps required to initiate opertaion of the MT-9500 with the GPIB interface. MT-9500 implementation is dependant on the system firmware level. Units with firmware level x2.9 or lower must refer to Method A.

Users with firmware level x3.0 or higher can use Method A or the enhanced Method B.

Users may verify whcih firmware level their MT-9500 contains by powering up the recorder and observing the LED display. The LED will indicate <SELF TEST>, followed by the firmware level in a message resembling <SCN 12.8>.

To select the GPIB implementation, the user should set dip switch #6 on the rear panel as follows prior to power-up:

OFF original **Method A** GPIB implementation (or RS-232)
ON Enhanced **Method B** GPIB implementation

Method A - Original GPIB Implementation
(Rear panel dip switch #6 OFF)

Method A GPIB implementation consists of the functions listed below. Various functions have allowable subsets:

SH1	Complete source handshake
AH1	Acceptor handshake
T8	Basic talker
TE0	No extended talker
L3	Basic listener
SR0	No service request capability
RL0	No remote/local capability
PP0	No parallel poll capability

DC0	No device clear capability
DT0	No device trigger capability
E2	Tri-state drivers

The MT-9500 recorder has a versatile and straightforward protocol of commands which may be transferred from a host computer. All global functions of the recorder generally, those (functions which affect all eight channels) may be controlled from the host. Also, special functions such as high resolution bit-mapped plotting, page and line printing, and saving/loading of captured waveform data are accessible via GPIB. This protocol is designed to work identically for both RS-232 and GPib interfaces, and is completely described in the MT-9500/ MT-8800 Host Control Manuals.

Programming the MT-9500 consists of transferring various escape code sequences, control sequences, and listening to responses back from the MT-9500. The responses serve the purpose of informing the host computer of errors (like invalid commands), as well as whether an operation has been completed.

Problems with programmming the MT-9500 with the original GPIB implementation are typically due to the user making assumptions about which state functions are implemented, since the early versions of the MT-9500 does not specify much about the actual implementation. As long as the control program is developed in accordance with the MT-9500 protocol, and the state functions listed above, the user should have a higher degree of success.

For the purposes of completeness and redundancy, further detail about MT-9500 programming utilizing **Method A** can be derived from the MT-9500 Host Control Manual.

Program Examples Using Method A

The MT-9500 Test and Demonstration Disk (OP-9500) that is supplied with the user's manual contains two programs which utilize the original **Method A** GPIB implementation. The first program, MT9500.BAS, is written in Basic and can control a single recorder. The second program MULT.BAS, is also written in Basic and is similar in structure to MT9500.BAS, but can control several recorders. Of course, users of GPIB may structure their control program much differently due to other devices which may be resident in their system.

Method B - Enhanced GPIB Implementation

firmware revision x3.0 or higher)

The enhanced **Method B** GPIB implementation on the MT-9500 has upgraded the state functions and their capabilities to improve overall GPIB system operation. **Method B** implementation is summarized below:

SH1	Complete source handshake
AH1	Acceptor handshake
T6	Basic talker with serial poll
TE0	No extended talker
L4	Basic listener
SR1	Service request capability
RL1	Complete remote/local capability
PP0	No parallel poll capability
DC1	Complete device clear capability
DT1	Complete device trigger capability
E2	Tri-state drivers

The enhanced GPIB implementation of **Method B** offers the following primary advantages:

1. Ability to gain control of the MT-9500 after power-up with virtually no local front panel keystrokes (Method A requires front panel [F2] [6] keying sequence)

2. Ability to perform device clear so that MT-9500 restores itself to a well-defined set of default conditions.

3. Group execute trigger capability.

4. Ability to notify the controller via SRQ interrrupt when the MT-9500 needs attention (i.e., paper out, command/data error, operation complete, etc.)

Getting Started - Address Assignment

The MT-9500 does not utilize dip switches for setting GPIB address, but rather a front panel entry scheme. To initialize an MT-9500 GPIB address the user should press [F2] [6] [ENTER] sequence to view/change the GPIB address. There are 31 valid addresses (00 - 30) that any MT-9500 recorder may be set to. Upon [ENTER], the MT-9500 has the new address. This address will be "remembered" in non-volatile RAM until changed by the user, and will not be lost when system defaults are reinstated, or when the power has been cycled on/off. Average non-volatile lifespan is 5 - 10 years.

After power-up, the MT-9500 may be operated

locally via the keypad or GPIB interface. See the MT-9500 Operations Manual for further detail about local operation.

Remote/Local Operation

The MT-9500 implements the complete RL1 function for remote/local operation. Upon REN message going true and the MT-9500 addressed listen, the MT-9500 will enter remote operation (REMS). At this point, control could be returned to local either through the front panel or by REN returning false. To prevent a local operator from being able to abort remote operation, the controller may send the LLO (Local Lock-Out) command. The GTL (Go To Local) multiline command will cause the MT-9500 to operate in a local fashion. When under GPIB control, the MT-9500 LED will display <GPIB xx>, where xx is the current address. A blinking dot will also appear in the LED display during remote operation.

Example: A typical sequence of events for start-up:

1. Power up MT-9500's and configure GPIB addresses via [F2] [6] [ENTER] keypad sequence (this needs to be done only once)
2. Place MT-9500's in the <READY> state (passed all SELF TESTS)
3. Control program sends Interface Clear (IFC)
4. Obtain control of MT-9500's by sending REN message true to all MT-9500's which are addressed to listen.
5. Control program sends Device Clear (DC), or Selected Device Clear (SDC) to MT-9500's to cause a return to default settings.
6. Optionally, transfer Local Lock-Out (LLO) command to prevent operator from obtaining control locally.
7. Enter main control program of operation.

If the MT-9500 has not recieved a Local Lock-Out (LLO), and operator may obtain local control by pressing [F2] [6] [ENTER] keypad sequence.

Mutilline Commands and the MT-9500

Multiline commands are defined as interface messages with the Attention (ATN) line true. These messages are sent by the controller to devices for command purposes. See appendix A for codes.

GTL (Go To Local)
Causes the MT-9500 to go to local operation. MT-9500 LED will display <READY>.

GET (Group Execute Trigger)
Causes the MT-9500 to start 8 channel analog real-time rcording, if the MT-9500 is presently in this mode. This command is similar in operation to the CONTROL-S (13H) command within the MT-9500 protocol.

DCL Device Clear
Causes all devices to restore parameter conditions to their default settings. MT-9500 default settings are listed in TAble 1 (below), and should noted by the user.

SDC Selected Device Clear
Causes only *addressed* devices to restore parameter conditions to their default conditions. See Table

LLO Local Lock-Out
Causes the MT-9500 to lock-out operators from returning the MT-9500 to local control. Attempts to restore local control will result in the MT-9500 LED to display <LOCK OUT>.

SPE Serial Poll Enable
Notifies all devices that the controller has placed the GPIB in the Serial Poll state.

SPD Serial Poll Disable
Notifies all devices that the controller has completed the Serial Poll.

MLA My Address Listen
Message/address to devices whose address is specified to enable listener status.

MTA My Talk Address

Message/address to devices whose address is specified to enable talker status.

UNL Unlisten
Command to enter the unlisten state.

UNT Untalk
Command to enter the untalk state.

Table 1 - MT-9500 Default Conditions

Mode Of Operation	IDLE mode, awaiting ESC sequence (new mode)
Grid Printing	on
Channel Order	12345678 (normal sequence)
Acquisition Time Base	1 ms/mm (highes resolution)
Storage Method/Window Size	8 channels/8 ksamples per channel
Window/Trigger Relationship	start trace (0% through the data)
X and Y Channels	X = 1, Y = 2
Playback Expansion Factor	x1 (none)
Trigger	on
Playback percentage	100% (complete playback)
Signal Polarity	NNNNNNNN (all non-inverted)
Motor Speed clock source	internal
Time Base clock source	internal
Numeric listing calibration (data log)	all 8 channels set to LS = +200, RS = -200, EXP = 2
Interchannel Text Buffers	spaces (none)
Trigger Channel	signal 1
Signal Conditioner Reporting	NNNNNNNN (all disabled)
Service Request Mask Byte	00 (no service requests)

Read and Write Termination (EOI and EOS)

To transfer command and data strings (escape or control sequences) to the MT-9500, an EOI uniline message should be attached to the last code. EOS characters need not be attached to data strings as a manner of ending data messages.

To read data from the MT-9500, the user may terminate on a specific number of characters expected, or terminate on EOI. There are only a few modes of operation which transfer data to the controller-in-charge.

Serial Poll

The controller-in-charge performs a serial poll insearch of the device(s) that has requested service when in need of attention. The device which has been enabled and addressed responds with a STB (status byte) message.

The status byte returned by the MT-9500 contains information as to whether the MT-9500 requested service (rsv = 1), and if so, the reason. Each bit of the status byte has a unique message, and is shown below:

STB (status Byte) Message							
7	6	5	4	3	2	1	0
0	rsv	0	0	0	MC	DE	I

I (bit 0) - Interlock situation
DE (bit 1) - Command/data error
MC (bit 2) - Mode complete/operation completed

If an interlock situation occurs, the MT-9500 will not accept data until it has been corrected. The situation is usually solved by replacing the chart paper within the recorder, or closing the chart paper door.

Command error situation typically occur due to improper code sequences sent to the MT-9500, or when commands are sent that require an option which is not installed within the MT-9500. The **Mode Complete** message is identical in purpose as the 01H code of the original MT-9500 GPIB implementation. Users should utilize this capability to detect when the MT-9500 has completed non-continuous modes , such as FORMFEED, ACQUISITION and PLAYBACK. These modes will self-terminate when the operation has been completed. All other modes require the user to cause an exit (abort) of operation in orde to return the MT-9500 to an IDLE state.

MT-9500 Programming using Method B

This section assumes that the reader is familiar with the MT-9500 Host Control Manual. It is vital that the reader have a clear understanding of the MT-9500 program command structure. This information includes ESCAPE CODE sequences used to enter modes, and CONTROL CODE sequences within modes used to control recorder operation. The major difference between GPIB implementations is that acknowledge codes and error codes such as 11H, 05H, and the 01H code sent by the MT-9500 have been eliminated. The user may be informed that attention is needed, error, or aborting of operation by taking advanatge of the newly added Seivce Request and serial polling capabilities. Full remote/local control is available in the **Method B** enhanced GPIB implementation.

Users may choose to use the original GPIB implementation of the MT-9500, and, in doing so, must set rear panel dip switch #6 to the OFF position.

New Commands

To allow more flexibility for user implementing the enhanced GPIB/MT-9500 interface, a series of new commands have been made available:

1. Define Service Request Mask Byte

This command allows the user to define which situations may/may not cause a service request to occur within the MT-9500. This is a sub-command of the SET UP mode. The default value for this byte is 00, meaning that no service requests will be generated.

Command sequence:
After entering SET UP mode, send (14H, mask byte, 0DH)

Each bit in the mask byte is defined below, and if set to 1 will enable a service request if the situation occurs:

bit 0 - Interlock situation (paper out or door open)
bit 1 - Command/data error
bit 2 - Mode complete/operation completed, or exited successfully.

Other bits are reserved for future use, and should be left at zero (0).

Program Example Using Method B

Included in the MT-9500 Test and Demonstration disks (SCN# x3.0 or higher) is a program which utilizes the enhanced GPIB implementation. This program is called GPIB-EP.BAS, and is written in Bsic. It may be used as an example and modified by the user for an IBM PC environment. GPIB-EP.BAS demonstrates many of the operating modes of the MT-9500 using the added state functions described above in detail.

Key features of the enhanced GPIB implementation include:

1. Ability to gain control of the MT-9500 after power-up with virtually no local front panel keystrokes (Method A requires front panel [F2] [6] keying sequence)

2. Ability to perform device clear so that MT-9500 restores itself to a well-defined set of default conditions.

3. Group execute trigger capability.

4. Ability to notify the controller via SRQ interrrupt when the MT-9500 needs attention (i.e., paper out, command/data error, operation complete, etc.)

References:

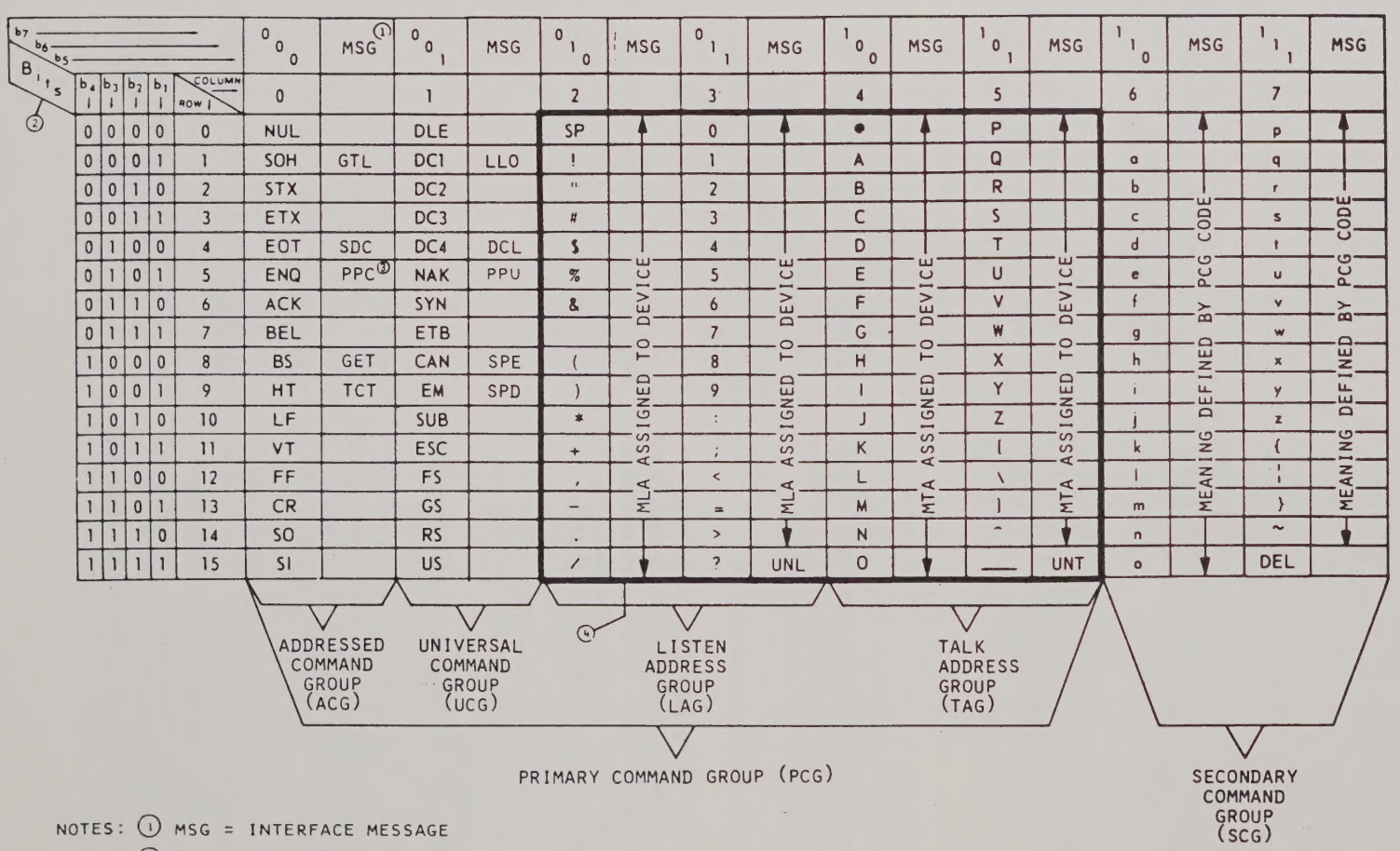
1. *Microcommunications Handbook*, Intel Corp. 1988

2. *488 Together with Code and Format Conventions*, Institute of Electrical and Electronics Engineers, Inc, 1983

Appendix A

Multiline Interface Messages Chart

(SENT AND RECEIVED WITH ATN=1)



b4	b3	b2	b1	ROW	COLUMN 0	COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6	COLUMN 7
					0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

	MSG		MSG		MSG		MSG		MSG		MSG		MSG		MSG
0		1		2		3		4		5		6		7	
0		DLE		SP		0		@		P		`		p	
1	GTL	DC1	LLO	!		1		A		Q		a		q	
2		DC2		"		2		B		R		b		r	
3		DC3		#		3		C		S		c		s	
4	SDC	DC4	DCL	$		4		D		T		d		t	
5	PPC[3]	NAK	PPU	%		5		E		U		e		u	
6		SYN		&		6		F		V		f		v	
7		ETB		'		7		G		W		g		w	
8	GET	CAN	SPE	(		8		H		X		h		x	
9	TCT	EM	SPD	)		9		I		Y		i		y	
10		SUB		*		:		J		Z		j		z	
11		ESC		+		;		K		[		k		{	
12		FS		,		<		L		\		l		|	
13		GS		-		=		M		]		m		}	
14		RS		.		>		N		^		n		~	
15		US		/		?	UNL	O		_	UNT	o		DEL	

NOTES: (1) MSG = INTERFACE MESSAGE
(2) b_1 = DIO1...b_7 = DIO7
(3) REQUIRES SECONDARY COMMAND
(4) DENSE SUBSET (COLUMN 2 THROUGH 5)

Appendix B

MT-9500 DIP Switch Settings (Updated)

	sw1	sw2	sw3	sw4	sw5	sw6	sw7	sw8
Normal Time	on	on	*	off	off	*	x	x
IRIG A	off	on	*	off	off	*	x	x
IRIG B	on	off	*	off	*	*	x	x
IRIG H	off	off	*	off	off	*	x	x
NASA 36	on	on	*	on	*	*	x	x
REMOTE START/STOP								
Enable operation	*	*	on	*	*	*	x	x
Disable operation	*	*	off	*	*	*	x	x
SYSTEM LOG PRINT CONTROL								
Synchronized (IRIG B and NASA 36 only)					on	*	x	x
Unsynchronized (all time codes)					off	*	x	x
COMMUNICATIONS SET-UP								
Original GPIB or RS-232	*	*	*	*	*	off	x	x
Enhanced GPIB	*	*	*	*	*	on	x	x

Note: x = reserved for future use, and should be placed in the **off** position.

Astro-Med, Inc.

Astro-Med Industrial Park • 600 East Greenwich Avenue •
West Warwick • R.I. • 02893 • (401)828–4000

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